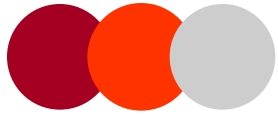# *Importance of Pavement Marking Retroreflectivity Standards*

Paul Carlson, Ph.D., P.E.
Research Engineer
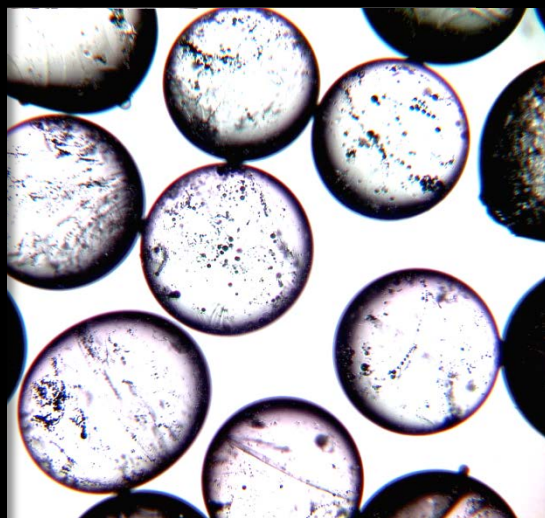## Texas A&M Transportation Institute
Texas A&M University

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TTI's Visibility Research Laboratory

- **Research aspects of traffic control materials with emphasis on safety and visibility**
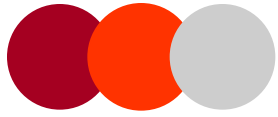
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ASTM Standards

- **ASTM E1710-11** Dry Handheld Test Method
- **ASTM E2177-11** Wet Recovery Handheld Test Method
- **ASTM E2176-08** Wet Continuous Handheld Test Method
- **ASTM E2832-12** Wet Continuous Handheld Test Method
- **ASTM D7585-10** Handheld Sampling Protocol

- **ASTM WK3833** Mobile pavement marking Work Item
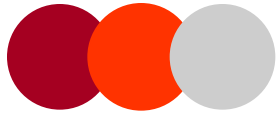
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ASTM E1710-11

- **Measurements of dry pavement marking retroreflectivity**
- **Defines instrument geometry**
- **Refers to D7585 for sampling plan**
- **"surface of marking shall be clean and dry"**
- **Recently added Precision Bias statement**
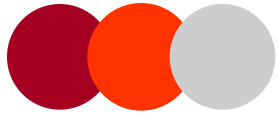
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Precision & Bias

○ **Testing completed in Feb 2010**

E1710 P&B Table

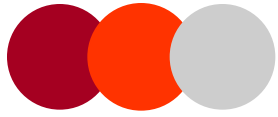| Sample	Average of the Labs' Averages	R/mean
N	575.8	11 %
D	331.4	12 %
Ap	266.5	16 %
O	508.7	17 %
R	1310.8	18 %
At	302.7	22 %
K	1854.7	22 %
Q	1985.8	25 %
H	584.6	26 %
F	519.8	28 %

ASTM E2177-11

- **Measurement of wet recovery (after rain)**
- **Currently includes option for dump or spray method**
- **Recently added Precision Bias statement**
- **Most commonly specified wet TM**

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Precision & Bias

o **Testing completed in Feb 2010**
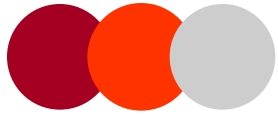

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ASTM E2176-08

- **Measurement of continuously wetted pavement markings (during rain)**
- **Limited to markings with optics having index of refraction greater than 2.0 and structured markings having vertical surfaces > 3 mm**
- **Controversial (wetting rate > 9 iph)**

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WITHDRAWN

ASTM E2832-12
NEW

- **Measurement of continuously wetted pavement markings (during rain)**
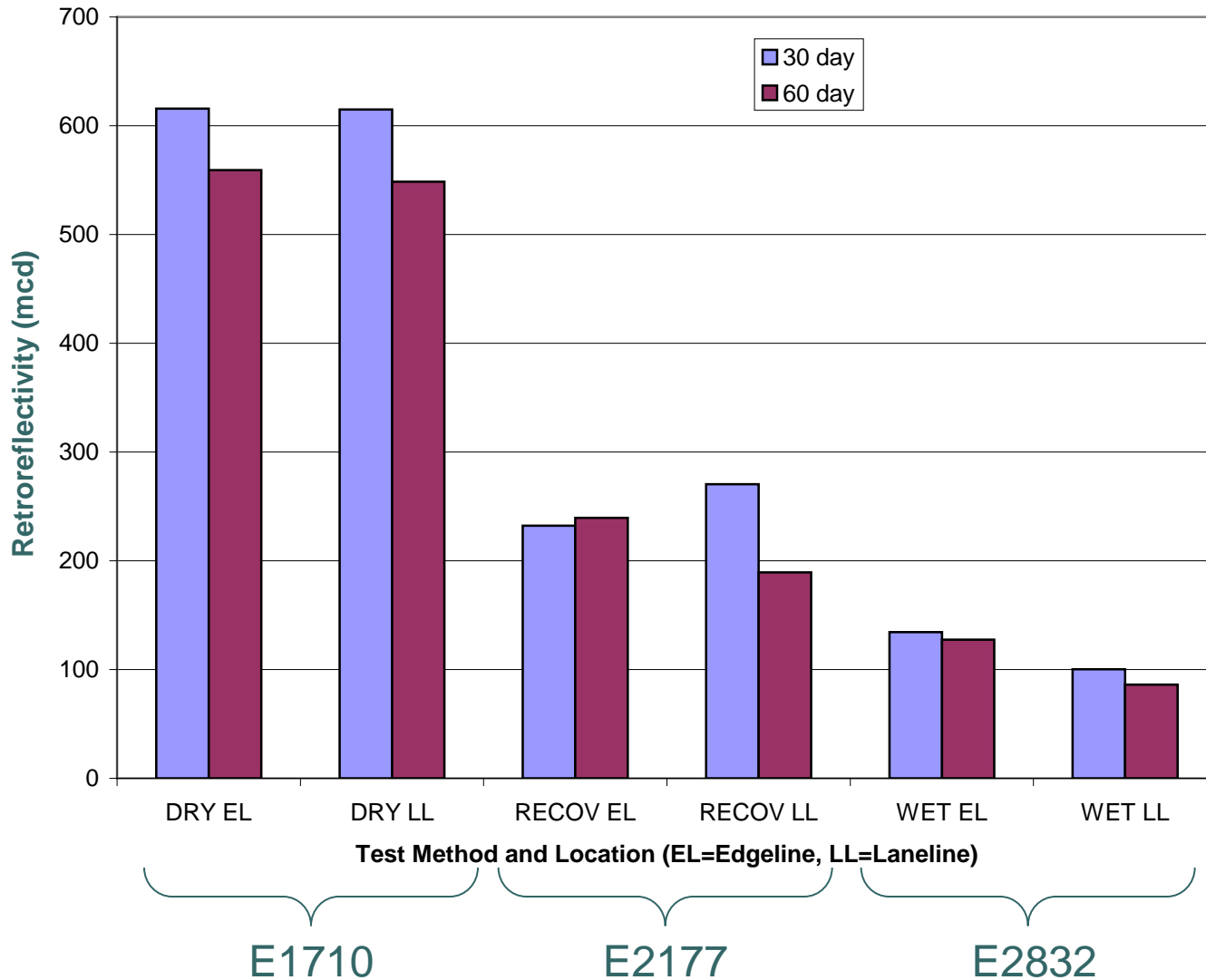- **Based on wetting rates of 2 inches per hour**
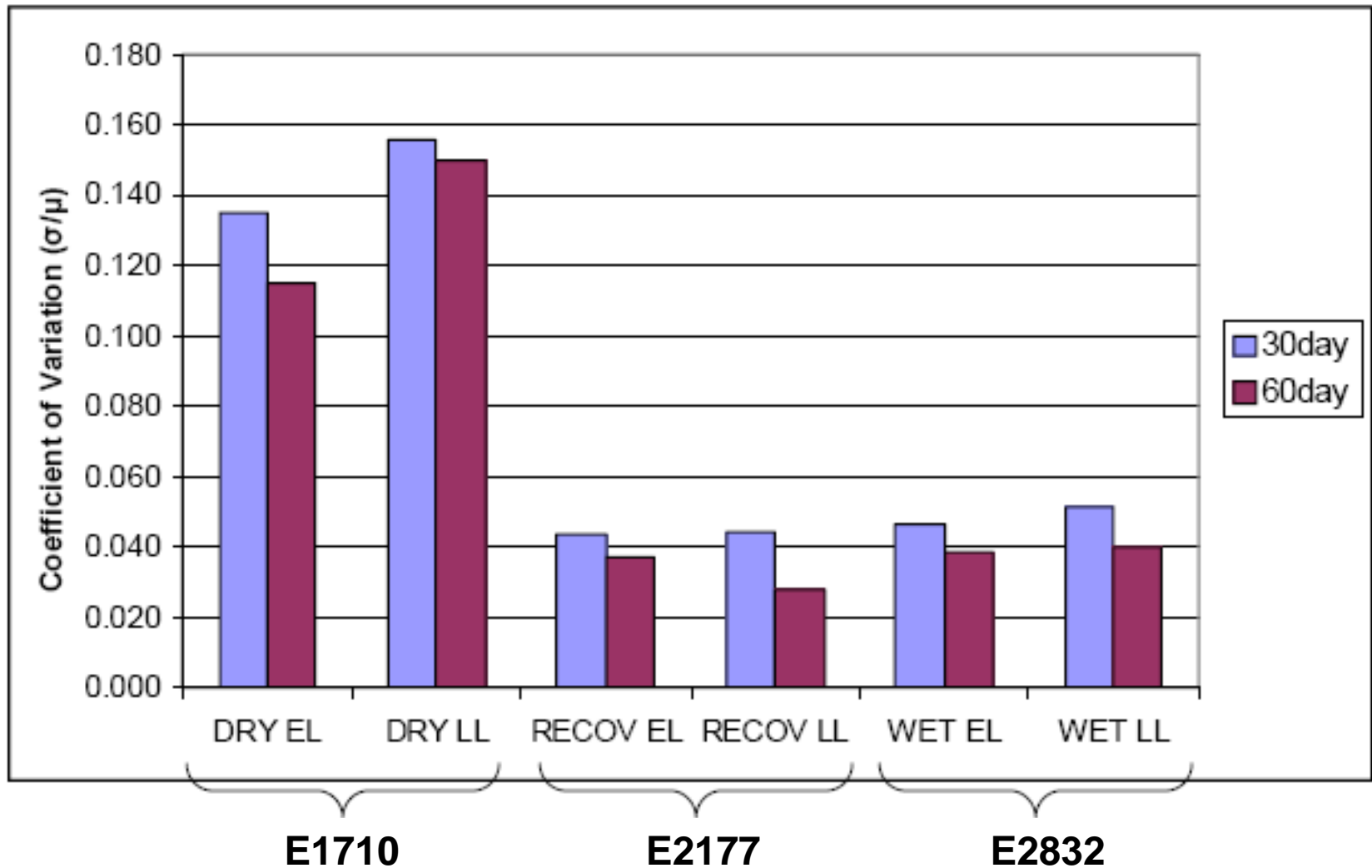
IBTTA

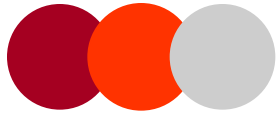TOLLING. MOVING SMARTER.

E2832 Field Data

E2832 Dispersion

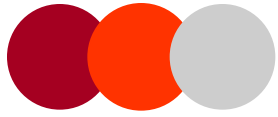Average of 8 Pvmt Mrkg systems (4 binders with 2 different optics each)

ASTM D7585-10

- Sampling protocol for using handheld retroreflectometers

- 3 field techniques, including number of measurements needed

- Does not set initial or maintained minimum R_L levels

- Released August 2010

ASTM D7585-10

- **Evaluation techniques**
  - Nighttime Visual Inspection
  - Standard Evaluation Protocol
  - Referee Evaluation Protocol
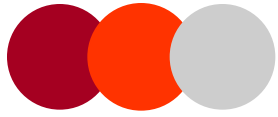
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ASTM D7585-10
Nighttime Visual Inspection

- **New or in-service markings**

- **Look for low brightness or high variability**
  - If any, conduct daytime inspection using Standard Evaluation protocol
  - If none, record 4 random measurements

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ASTM D7585-10
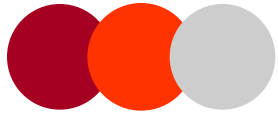## Standard Evaluation Protocol

- **Intended for longitudinal markings**
- **Evaluation sections: 400 ft (minimum)**
- **At least 16 readings per evaluation section**
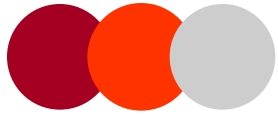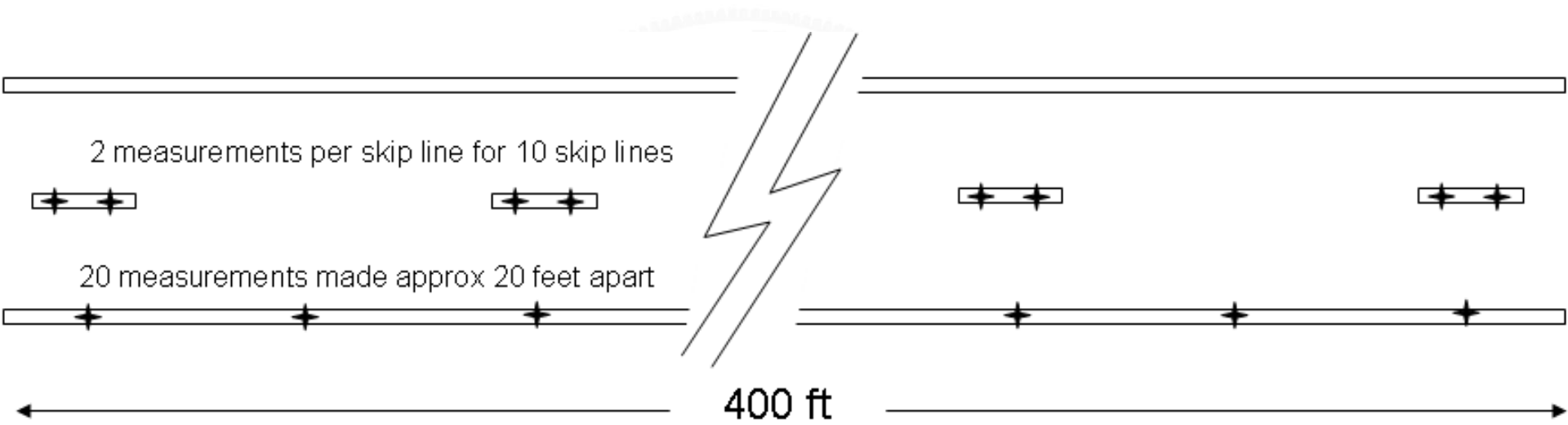 - Based on statistical valid sample sizing

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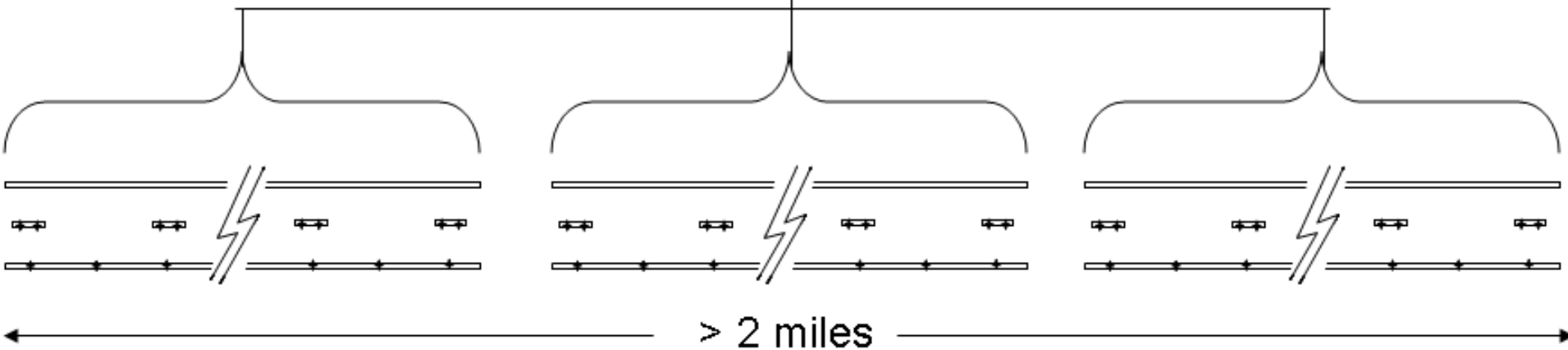TOLLING. MOVING SMARTER.

Evaluation Section: Less than 2 miles

2 measurements per skip line for 10 skip lines

20 measurements made approx 20 feet apart

400 ft

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INTERNATIONAL BRIDGE, TUNNEL AND TURNPIKE ASSOCIATION

Evaluation Section: More than 2 miles

Three evaluation sections as shown in Figure 1.

> 2 miles

ASTM D7585-10
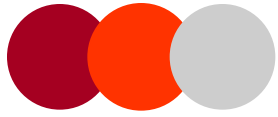## Referee Evaluation Protocol

- Most rigorous protocol

- Minimum of 20 measurements per Evaluation Section

- Includes all marking types such as arrows and gore markings
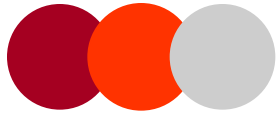
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ASTM WK3833

- **In-development**
- **Test method for mobile pavement marking retroreflectivity measurements**
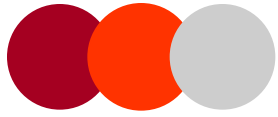

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Why is this important?

- **FHWA is working on minimum maintained pavement marking retroreflectivity levels for the MUTCD**

- **Once adopted, agencies will have to maintain pavement marking retroreflectivity**

Manual on Uniform Traffic Control Devices
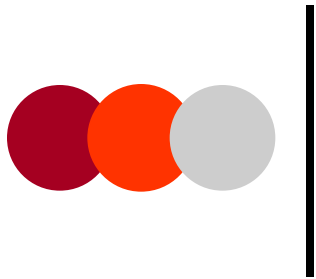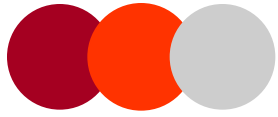for Streets and Highways
2009 Edition
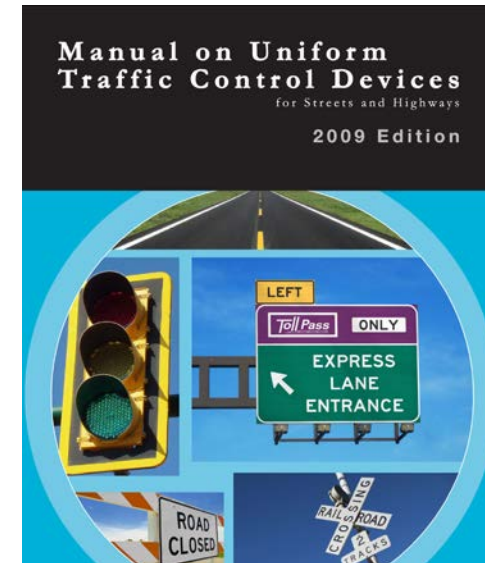
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Pavement Marking Retroreflectivity = Safety

- *An Investigation of Longitudinal Pavement Marking Retroreflectivity and Safety*
  - TRB Annual Meeting, Paper Number 13-2512

- **Objective**
  - Determine whether a correlation exists between pavement marking retroreflectivity and safety

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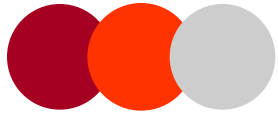
Our Approach

- **Merge Michigan crash, roadway, and retroreflectivity databases**
  - Rural two-lane highways and freeways
  - Only non- intersection/interchanges segments
  - Only nighttime crashes
  - Only non-winter data from 2002 to 2008
    - April to October (7 months per year)

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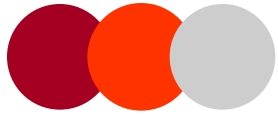
Retroreflectivity Data

- **About 25,000 measurements**
- **Mobile measurements (1.25 million readings)**
- **About 15% of the state system each year**
- **Four line types**
  - White edge line, white lane line
  - Yellow edge line, yellow center line
- **Michigan restripes about 80-85% of their system each year**

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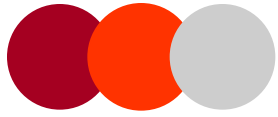# Distribution of Retro by Line Type
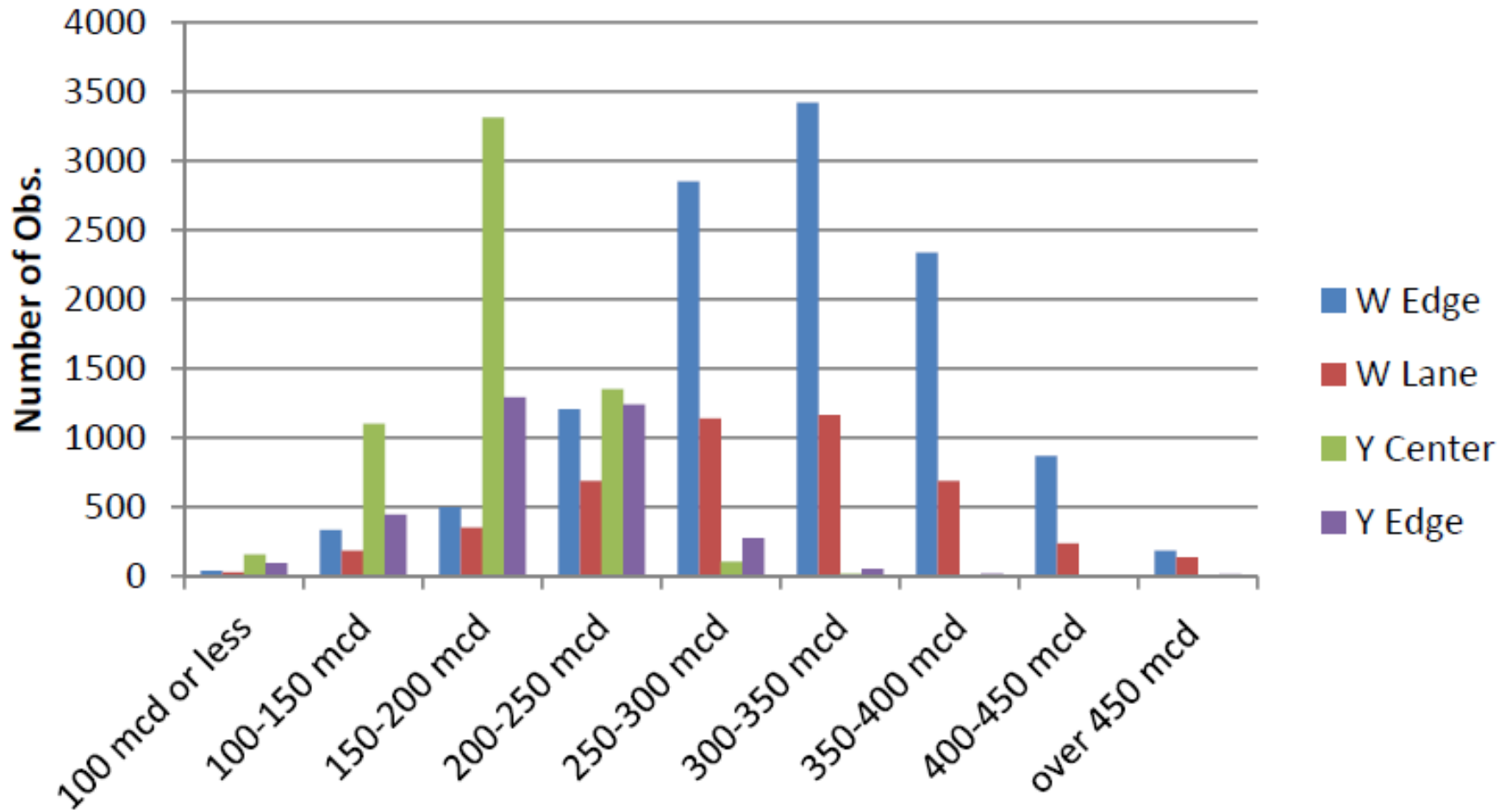
Database Development

- **For each segment, 49 time periods**
  - 7 years, 7 months per year
- **To populate retro for each segment**
  - Temporal imputation
    - Rules for degradation per month generated from subset of data
  - Spatial imputation
    - Backward and forward imputation performed

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Analyses Technique

- **Negative binomial regression with Generalized Estimating Equations (GEE)**

- **Analyses were conducted 4 ways:**
  - With all the retro data
  - With retro data < 200 mcd
  - With retro data < 150 mcd
  - With retro data < 100 mcd
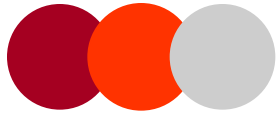
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Partial Findings: Single Vehicle Nighttime Crashes on Freeways

- **White edge lines**
  - NB coeff. -0.009 *(statistically significant)*
  - Increase retro by 10 mcd → 0.9% reduction
  - Increase retro by 100 mcd → 8.6% reduction
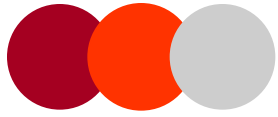- **Yellow edge lines**
  - NB coeff. -0.013 *(statistically significant)*
  - Increase retro by 10 mcd → 1.3% reduction
  - Increase retro by 100 mcd → 12.2% reduction

Suggested Actions

- **Get ahead of FHWA**
- **Implement minimum pavement marking retro standards for long line markings**
- **Use warranty or performance specifications with ASTM test methods**

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